ARL-TR-92-9

Copy No. 14

ONR Basic Research Program: Summary and Bibliographies

Annual Reports under Grant N00014-90-J-1366, FY90 and FY91

Thomas G. Muir

Applied Research Laboratories
The University of Texas at Austin
P. O. Box 8029 Austin, TX 78713-8029

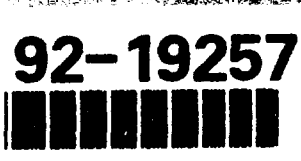
19 May 1992

Annual Reports

1 October 1989 - 30 September 1991

Approved for public release; distribution is unlimited.

Prepared for:
Office of the Chief of Naval Research
Department of the Navy
Arlington, VA 22217-5000



REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	19 May 1992	annual 1 Oct 89 - 30 Sep 91

4. TITLE AND SUBTITLE
ONR Basic Research Program: Summary and Bibliographies
Annual Reports under Grant N00014-90-J-1366, FY90 and FY91

5. FUNDING NUMBERS
N00014-90-J-1366

6. AUTHOR(S)
Muir, Thomas G.

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES)
Applied Research Laboratories
The University of Texas at Austin
P.O. Box 8029
Austin, Texas 78713-8029

8. PERFORMING ORGANIZATION REPORT NUMBER
ARL-TR-92-9

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of the Chief of Naval Research
Department of the Navy
Arlington, Virginia 22217-5000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)
Research conducted under the subject contract is surveyed from a bibliographical perspective based on an inventory of published research. This survey is intended to be useful in managerial evaluation of the funded research program.

14. SUBJECT TERMS
(see reverse side)

15. NUMBER OF PAGES
30

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

14. (cont'd)

parabolic wave equation
benchmark wedge
shear wave velocity
lazy matching
underwater arc sound source
active control processes
Cohen harmonic transforms
plasma sound source
airborne acoustics
Bering Strait
wideband monopulse sonar
TREAT-based production system compiler
active database system
fluid structural interactions
GPS surveying
bubbly media
distinct phenomenon
Norwegian Sea
subsystem clock board
OpsStat2

TABLE OF CONTENTS

1. INTRODUCTION

The subject grant was issued on 1 October 1989 in response to Applied Research Laboratories, The University of Texas at Austin (ARL:UT), proposal P-1502, dated 17 August 1989,[1] providing $279K of support for FY90. This grant was funded out of the Office of the Chief of Naval Research (ONR) discretionary block for support of this laboratory as well as Applied Research Laboratory, Pennsylvania State University (ARL/PSU), Applied Physics Laboratory, University of Washington (APL:UW), and Marine Physics Laboratory, Scripps Institution of Oceanography, University of California at San Diego (MPL:SIO:UCSD). This block is administered by Dr. Marshall Orr, with the assistance of Dr. Ralph Baer and Mr. Marvin Blizzard, ONR Code 1125OA. The purpose of the discretionary grant program is to give the laboratory directors freedom to develop and apply their resources to basic research problems of naval relevance, which may not be known or appreciated by others in the community. The guidelines of the program include (1) involvement of students and faculty, and (2) initiation of research in areas that could transition into either core or special research initiative (SRI) programs at ONR.

Support for ARL:UT in FY90 was for six research problems, funded as shown in Table 1.1. This includes the first modification of the grant, issued on 8 June 1990 in response to ARL:UT proposal P-1512, dated 20 March 1992,[2] which added $20K in support of the last listed project, below.

TABLE 1.1

Research Project	Principal Investigator	Funding
Basic Research	Dr. Muir	$75K
Structural Acoustics	Prof. Stearman	$119K
Thermoacoustic Instability and Chaotic Systems	Profs. McCormick and Griffy	$27K
Defense Science and Engineering Apprenticeship Program	Dr. Muir	$21K
Spark Source Theory	Profs. Gleeson and Griffy	$38K
Nonlinear Noise Mechanisms in Bubbly Oceans	Prof. Vishniac	$20K

As can be seen, the largest research project was structural acoustics, which was a special focused program, in contradistinction to the other projects, which were traditional professor-student projects. A special focused program was requested by ONR, and ARL:UT chose this one based on a lab-wide competition. The motivation behind this program was to involve faculty, students, and ARL:UT research staff in a research project large enough to enter an area new to the laboratory.

The subject grant was renewed on 20 November 1990 in response to ARL:UT proposal P-1522, dated 26 September 1990,[3] providing $291K of support for FY91 on seven research projects, funded as shown in Table 1.2. This includes a modification of the grant, issued on 3 September 1991 in response to ARL:UT proposal P-1550, dated 17 June 1991,[4] which added $8K to support project (the long term high school apprenticeship modification), below. That project provided support for high school apprentices during the long term. This long term apprenticeship program is in addition to the longstanding high school apprenticeship program, which is run during the summer months only.

TABLE 1.2

Research Project	Principal Investigator	Funding
Structural Acoustics	Prof. Stearman	$119K
Thermoacoustic Instability and Chaotic Systems	Profs. McCormick and Griffy	$27K
Defense Science and Engineering Apprenticeship Program	Dr. Muir	$21K
Spark Source Theory	Profs. Gleeson and Griffy	$38K
Expert Database System	Prof. Miranker, Mr. Brant	$80K
Nonlinear Noise Mechanisms in Bubbly Oceans	Prof. Vishniac	$20K
Long Term High School Apprenticeship	Dr. Muir	$8K

Statistics on projects, students, faculty, etc., are shown in Table 1.3 for FY87 through FY91.

TABLE 1.3

ONR "ARL" PROGRAM

Purpose:

- Seed money - new 6.1 research
- Support UT professors and students on problems of Naval relevance
- Support High School Apprenticeship Program

Administration:

- Dr. Marshall Orr, ONR 11250A
- Individual ONR project officers
- ARL IR&D coordinator

	FY87	FY88	FY89	FY90	FY91
$K	285.1	280.7	133.0	299.3	291.0
# Active projects	10	13	11	5	6
# Students	10	12	11	5	7
# Faculty	8	11	9	4	6

2. RESEARCH RESULTS

The following bibliographical abstracts serve to summarize the scientific documentation produced under this grant. We include work that may have begun under the preceding ONR discretionary grant,[1] but was either finished or reported during the subject grant.

2.1 ARCHIVAL PUBLICATIONS

Here we present the bibliographical data as well as the abstract of each paper that appeared in refereed journals. We also include publications that have been submitted, but are still in the journal editing process, which is sometimes quite lengthy.

1. Darvennes, Corinne M., and Mark F. Hamilton (1990). "Scattering of Sound by Sound from Two Gaussian Beams," *J. Acoust. Soc. Am.* **87**(5), 1955-1964.

   The scattering of sound by sound from Gaussian beams that intersect at small angles is investigated theoretically with a quasilinear solution of the Khokhlov-Zabolotskaya nonlinear parabolic wave equation. The closed form solution, which is valid throughout the entire paraxial field, is a generalization of a result obtained previously for parametric receiving arrays [Hamilton et al., J. Acoust. Soc. Am. **82**, 311-318 (1987)]. Significant levels of scattered sum and difference frequency sound are shown to exist outside the nonlinear interaction region. An asymptotic formula reveals that sound is scattered in the approximate directions of $\mathbf{k}_1 \pm \mathbf{k}_2$, where k_j is the wave vector associated with the axis of jth primary beam. Computed propagation curves and beam patterns demonstrate the dependence of the scattered radiation on interaction angle, source separation, ratio of the primary frequencies, and source radii. Comparisons are made with the farfield results by Berntsen et al. [J. Acoust. Soc. Am. **86**, 1968-1983 (1989)], which are valid for arbitrary interaction angles, source separations, and amplitude distributions.

2. Lacker, S. G., and T. L. Henderson (1989). "Wideband Monopulse Sonar Performance: Cylindrical Target Simulation Using an Acoustic Scattering Center Model," *IEEE J. Oceanic Eng.* **15**(1), 32-43.

An ahead-looking sonar can be used in the underwater environment for obstacle avoidance and observation of seafloor features. Single frequency, split-aperture sonar systems are useful in these applications, but a wideband monopulse sonar is preferable because of its performance characteristics. Previous theoretical studies of this type of sonar have been limited to very simple seafloor geometries and have scarcely addressed the response to objects in the ocean volume. A time-domain simulation which lends itself to the study of complex ocean environments, including complex seafloor shapes and suspended objects, has been developed. This simulation is used to study the response of a monopulse sonar to the presence of rigid cylinders near the seafloor. An acoustic scattering center model is developed to represent the cylinders, and several examples are presented and discussed.

3. Westwood, Evan K. (1990). "Ray Model Solutions to the Benchmark Wedge Problems," *J. Acoust. Soc. Am.* **87**(4), 1539-1545.

A ray method is used to calculate the acoustic field in the shallow-water, penetrable wedge problems proposed as benchmarks by the Acoustical Society of America. Agreement is excellent between the ray solution and the two-way coupled-mode solution. The ray approach not only constitutes an independent method for comparison with other models, but also provides an intuitive picture of the propagation in terms of eigenrays. An analysis of the eigenray information provided by the ray model reveals that the effects of backscatter are totally insignificant for the penetrable wedge problems considered. The computation time required on a Cyber 180-830 to calculate the field at a single point varies from 5 s near the source to 60 s near the apex of the wedge. The calculation of the field at 400 points along a horizontal line requires less than 10 min.

4. Miranker, D., B. J. Lofaso, G. Farmer, A. Chandra, and D. Brant (1990). "On A TREAT-Based Production System Compiler," Proceedings of the

10th International Workshop on Expert Systems and Their Applications, Avignon, France, 617-630.

This paper describes the techniques used to develop a TREAT-based optimizing compiler for the OPS5 production-system language. We present our results with respect to the usefulness of a new heuristic joint optimization strategy, the introduction of domain-based indexing and the proportion of time spent in each phase of the production system cycle. The combination of the TREAT algorithm and the compiling techniques has substantially reduced the proportion of time spent in the match phase below the "greater than 90%" figure often cited by developers of other production system environments. To show that these results are not an anomaly of the implementation we compare our performance to the newest optimized RETE based OPS5 compiler recently released from Carnegie Mellon University.

5. Collins, Michael D., and Evan K. Westwood (1990). "A Two-Way Parabolic Equation for Acoustic Backscattering in the Ocean," *J. Acoust. Soc. Am.* **91**(3), 1357-1368.

The parabolic equation (PE) method is generalized to handle backscattered acoustic energy in the ocean. The two-way PE is based on the single-scattering approximation and the approach of two-way coupled modes in which range-dependent environments are approximated by a sequence of range-independent regions. At the vertical boundaries between regions, the solution of the two-way PE is required to satisfy two continuity conditions. The range derivative in one of the conditions is replaced by a higher-order PE depth operator. The reflected and transmitted fields that satisfy these conditions are computed with an efficient iteration scheme. The outgoing and incoming fields are propagated by two-way range marching. The two-way PE, which is presently implemented for two-dimensional problems, is a practical method for solving large-scale reverberation problems. The accuracy of the two-way PE is demonstrated by comparisons with reference solutions. The two-way PE is applied to simulate the localization of a source of backscattering using the method of back propagation.

6. Muir, T. G . et al. (1991). "Comparison of Techniques for Shear Wave Velocity and Attenuation Measurements" in Shear Waves in Marine Sediments, Jens M. Hovem et al., eds., Kluwer Academic Pubs., Proceedings of the Conference held at La Spezia, Italy, October 15-18, 1990. (This was a refereed proceedings.)

In order to support ocean acoustic modeling and sonar performance prediction, it is necessary to acquire geoacoustic data on sediment structure. The direct measurement of shear wave velocity and attenuation within the sedimentary volume is a difficult and time consuming process. More rapid, remote measurements involving inversion techniques are evolving, but their evaluation requires "ground truth" data obtained by direct measurements. A comparison of various "in situ" methods used at SACLANTCEN is presented to illustrate the development of testbed sites where ground truth data is obtained. These methods include 1) near surface measurements with bimorph transducer, 2) downhole measurements with impact sources and geophone receivers, 3) explosive shot measurements with bottomed and buried seismographs, and 4) measurements with explosive sources and line arrays of geophones. The role of these methods in the evolution of rapid remote sensing techniques is discussed.

7. Miranker, D. P., and B. J. Lofaso, Jr. (1991). "The Organization and Performance of a TREAT-Based Production System Compiler," *IEEE Trans. Knowledge and Data Eng.* **3**(1), 3-10.

Performance issues often prevent prototype production system programs from scaling to large deliverable systems. In this paper, we will describe an ensemble of techniques that compile OPS5 production system programs to executable machine code and demonstrate an increase in the execution speed of production system programs by two orders of magnitude over the commonly used LISP-based OPS5 system.

The compiler is based on the TREAT incremental match algorithm. In this paper, we present a version of the TREAT algorithm, formulated in relational algebra and prove the algorithm correct. The compiler employs

optimization techniques derived from relational database systems. Furthermore, the combination of the TREAT algorithm and the compiling techniques has substantially reduced the proportion of time spent in the match phase below the "greater than 90%" figure often cited by developers of other production system environments. To show that these results are not an anomaly of the implementation we compare our performance to the newest optimized RETE-based OPS5 compiler recently released from Carnegie Mellon University.

2.2 NON-ARCHIVAL PUBLICATIONS

Bibliographical data and abstracts for a paper that appeared in a non-refereed publication, such as the proceedings of symposia, etc., are presented here, along with the dates, location, sponsor, and special topic of the publication.

1. Miranker, D. P., D. A. Brant, B. J. Lofaso, Jr., and D. Gadbois (1990). "On the Performance of Lazy Matching in Production Systems," Proceedings of the Eighth National Conference on Artificial Intelligence, 685-692.

   Production systems are an established method for encoding knowledge in an expert system. The semantics of production system languages and the concomitant algorithms for their evaluation, RETE and TREAT, enumerate the set of rule instantiations and then apply a strategy that selects a single instantiation for firing. Often rule instantiations are calculated and never fired. In a sense, the time and space required to eagerly compute these unfired instantiations is wasted. This paper presents preliminary results about a new match technique, lazy matching. The lazy match algorithm folds the selection strategy into the search for instantiations, such that only one instantiation is computed per cycle. The algorithm improves the worst-case asymptotic space complexity of incremental matching. Moreover, empirical and analytic results demonstrate that lazy matching can substantially improve the execution time of production system programs.

2. Miranker, D. P., and D. A. Brant (1990). "An Algorithmic Basis for Integrating Production Systems and Large Databases," Proceedings, Sixth International Conference on Data Engineering, 353-360.

Due to the similarities between AI production rules and relational database queries with updates, it appears straightforward to integrate the two systems to form an *active database system*. However, a large rule system represents on the order of hundreds or thousands of concurrent transactions, each repeated on every cycle. Executing such a large number of transactions on a large database within a short amount of time is computationally stressful. Main-memory resident production systems have been made computationally feasible by the development of incremental match algorithms that exploit the temporal redundancy of the database by saving results computed in minor cycles. Unfortunately, the worst-case space complexity of these match algorithms is exponential and space management becomes a dominant issue. In this paper we present a lazy incremental main algorithm with linear worst-case space complexity. Moreover, initial empirical results show that we prune 60% of the search for rule instantiations. We feel that these results produce the first reasonable algorithmic basis upon which one can develop an active database system.

3. O'Donnell, R. B., R. O. Stearman, W. E. Brown, E. J. Powers, and G. R. Wilson (1991). "Factors Contributing to the Nonlinear Acoustic Response in Fluid Structural Interactions," Proceedings of the 9th International Modal Analysis Conference, Florence, Italy, 14-18 April 1991.

The results of a theoretical analysis and an experimental study are presented for the nonlinear vibration and acoustic response of a thin cylindrical shell structure. The generalized equations of motion for the thin shell, without preload, demonstrate a cubic type of nonlinearity of the geometric stiffness type. An experimental acoustic response study of an unstressed, excited thin cylindrical shell, however, revealed, through higher order signal processing techniques, a dominant presence of a quadratic type of nonlinearity. Following the theoretical development of

Liu and Arbocz, geometric imperfections, initial preload, and orthogonal stiffening were then introduced into the nonlinear shallow shell equations. A dynamic solution of the resulting generalized equations was then shown to produce quadratic type nonlinear contributions to the overall calculated shell displacement response. That is, good agreement was obtained between theory and experiment when the effects of geometric imperfections were included in the theoretical modeling of the shell. While the use of an active control feedback system was beneficial in silencing the acoustic response from the fundamental tones of the shell vibration, significant spillover of the actively controlled response was observed in the higher order spectral domain.

4. Rogers, R. L. (1991). "An Underwater Arc Sound Source in an Open Ocean Environment," Proceedings of the ONR Workshop on Thermal Acoustic Generation, 3-4 April 1991, at ARL:UT, Austin, Texas.

This is the transcription of a workshop in which thermoacoustic methods for generating sound were discussed. Several categories of these devices were examined for suitability for generating high intensity low frequency sound. Thermoacoustic resonators, laser sources, and impulsive sources were primarily discussed. In addition, MHD sources and bubble sources were compared for their performance in generating sound.

5. Brant, D. A., T. Grose, B. J. Lofaso, Jr., and D. P. Miranker (1991). "Effects of Database Size on Rule System Performance: Five Case Studies," Proceedings of the 17th International Conference on Very Large Databases, Barcelona, Spain, 3-6 September 1991.

Building practical expert database systems requires an effective inferencing capability over large data sets. Inferencing in this context means repeatedly executing a fixed set of queries, interleaved with update transactions, until a fixed point is reached. The effectiveness of the inferencing mechanism is heavily dependent upon the amount of state space needed and the ability of the underlying algorithms to avoid unnecessary work. Common techniques used in the design of rule-based systems store large amounts of state in order to derive precise query

support information that will enable better performance. These techniques were intended for use in main memory on small data sets and are not necessarily suited for a database environment. When confronted with a large database these techniques may experience severe performance problems - severe enough to render them useless. In this paper we examine the effects of database size on five test cases. The use of real programs with real data provides insights that are not to be found through analysis and simulation. We compare two different rule systems, one based on the TREAT match algorithm and the other on LEAPS, a lazy matching algorithm. The results show that state can be a problem in rule systems and that by using lazy matching it is possible to eliminate some state while improving performance.

2.3 COMPLETED DISSERTATIONS AND THESES

Bibliographical and biographical information on these fiducial academic documents is presented here on the research topics, the student graduates, their professors, and ARL:UT co-researchers, as well as their relationships within the academic and naval research and service communities. It should be remembered that each of the graduates is a U.S. citizen, and each is a potential candidate for a leadership role in the conduct of future naval research and development.

Dissertations

None

Theses

1. O'Donnell, R. B. (Electrical Engineering, 1990). "Bispectral Investigation of Active Control Processes," under G. R. Wilson (ARL:UT) and R. O. Stearman (UT and ARL:UT); worked with W. E. Brown (ARL:UT) and Ed Powers (UT); graduate of U.S. Naval Academy; attended nuclear power school and completed three and one-half year tour on USS JAMES K. POLK, qualified in submarines and as Engineer Officer for

nuclear-powered submarines, two-year tour with Naval Intelligence; presently employed at Bolt Beranek & Neuman, Washington, D.C.

2. Dahlke, Scott R. (Engineering, 1990). "Accuracy Limitations of GPS Surveying Using Mixed Receiver Types."

3. Sheehan, Jack H. (Engineering, 1990). "Some Properties of Cohen Harmonic Transforms in a Hilbert Space."

4. Miller, Elizabeth L. (Arts, 1990). "Propagation of Longitudinal and Shear Waves through Ice."

5. Bonin, Marc C. (Engineering, 1990). "Evaluation of a Computational Method for Modeling Sound Scattering by Submerged Structures."

2.4 DISSERTATIONS AND THESES IN PROGRESS

These projects were initiated under the subject contract and are listed below. Due to the aforementioned change in primary guidelines, many of these have now been reassigned to other funding sources, including ARL:UT Independent Research and Development (IR&D) funds.

Dissertations

1. LeMond, Julienne (Physics). "Thermo-Acoustic Instabilities in a One Dimensional System," under Dr. W. D. McCormick (UT); working with R. Koch (ARL:UT) and T. A. Griffy (UT).

2. Hawkins, James A. (Aerospace Engineering and Engineering Mechanics). "Acoustic Propagation in Bubbly Media," under A. M. Bedford (UT); working with D. T. Blackstock (UT and ARL:UT), J. N. Tjøtta (ARL:UT), and James A. TenCate (ARL:UT).

3. TenCate, James A. (Mechanical Engineering). "Scattering of Sound by Sound," under M. F. Hamilton (UT); working with D. T. Blackstock (UT and ARL:UT), J. A. Hawkins (ARL:UT), and J. N. Tjøtta (ARL:UT).

4. Cook, Jeffrey A. (Physics). "Physical Processes in the Plasma Sound Source," under Austin Gleeson (UT); working with R. L. Rogers (ARL:UT).

5. Roberts, Randy (Physics). "Bubble Dynamics in Plasma Sound Sources," under Thomas Griffy (UT); working with R. L. Rogers (ARL:UT).

6. Lamb, James (Mechanical Engineering). "Wave Number Interactions In Parametrically Excited Periodic Beams," under Ronald Stearman (UT and ARL:UT); working with G. R. Wilson, W. E. Brown, and J. H. Sheehan (ARL:UT).

7. Brant, David (Computer Science). "Toward an Expert Database System," under Daniel Miranker (UT and ARL:UT).

Theses

1. Fox, D. J. (Mechanical Engineering). "Wave Number Interactions in Parametrically Excited Periodic Beams," under R. O. Stearman (UT and ARL:UT); working with G. R. Wilson, W. E. Brown, J. H. Sheehan, and J. L. Lamb (ARL:UT).

2.5 PAPERS PRESENTED AT MEETINGS

Titles, authors, and meeting data are listed below. Almost all of these presentations will end up as archival papers such as those listed above. The presentation of scientific papers at meetings is a give-and-take process that enables the authors to receive criticism, comments, and an exchange of information that sharpens the work perspective and its ultimate relevance, prior to submission as an archival contribution.

1. Hawkins, J. A., Jr., and A. M. Bedford. "A Variational Model for Bubbly Liquids: Reflection from a Liquid-Bubbly Liquid Interface," 120th Meeting of Acoust. Soc. Am., San Diego, California, 26-30 November 1990.

2. Cook, Jeffrey A., Sirian Thepsoumane, Austin Gleeson, and Robert Rogers. "Studies of Various Electrode Configurations for a Plasma Sound Source," 120th Meeting of Acoust. Soc. Am., San Diego, California, 26-30 November 1990.

3. Hawkins, James A., and A. M. Bedford. "Variational Theory for a Partially Saturated Porous Medium with a Distribution of Bubble Sizes," 33rd Meeting of the Society for Natural Philosophy, Pittsburgh, Pennsylvania, 1 October 1989.

2.6 ARL:UT REPORTS

In addition to the archival papers, dissertations, theses, and other highly valued scientific documents cited above, there is a very real and important need for the publication of a variety of reports that are useful in the conduct of work. These include translations and analyses of foreign scientific literature, internal reports surveying technology, etc. These are listed below.

In order to facilitate the distribution of theses and dissertations (listed in Section 2.3 above), these are normally reissued as laboratory reports. Copies of most of these reports are available upon request to the ARL:UT Library, depending on the limitations on distribution.

1. Dahlke, Scott R. (1990). "Accuracy Limitations of GPS Surveying Using Mixed Receiver Types," Applied Research Laboratories Technical Report No. 90-10 (ARL-TR-90-10), Applied Research Laboratories, The University of Texas at Austin.

2. Muir, Thomas G., and Beverly E. Donoghue (1990). "ONR Basic Research Program: Summary and Bibliographies," Final Report under Contract N00014-87-K-0346, 1 June 1987 - 31 December 1989, Applied Research Laboratories Technical Report No. 90-24 (ARL-TR-90-24), Applied Research Laboratories, The University of Texas at Austin.

3. Muir, Thomas G., ed. (1991). "The Department of Defense Science and Engineering Apprenticeship Program for High School Students, Summer

Program 1990," Applied Research Laboratories Technical Report No. 91-5 (ARL-TR-91-5), Applied Research Laboratories, The University of Texas at Austin.

2.7 DoD SCIENCE AND ENGINEERING APPRENTICESHIP PROGRAM

The purpose of the apprenticeship program is to provide outstanding recent high school graduates with hands-on experience in a stimulating research environment and encourage them to pursue careers in the science and engineering disciplines, particularly in those areas related to the needs of the Department of Defense. Students were selected for this program on the basis of their academic records, scholastic aptitude test results, applications, and references from their teachers. Each student was assigned to a research project to be performed under the supervision of a research staff member at ARL:UT. At the end of the apprenticeship in mid-August, students gave oral presentations with visuals for the laboratory's directors and prepared short technical papers summarizing their projects' results. The annual reports included technical papers by the following student authors, whose abstracts are also included.

<u>1990 Participants</u>	
Denise Castillo	Simulation by Domestic Pigs of Acoustic Properties of Human Drowning Victims, Part II
Chris Matzner	Enhanced Nonlinear Scattering by Bubbles in Water and a Mechanism of Bubble Cloud Nonlinearity
A. J. Schwab	Production of a Sonar System
Stephen Fisher	Airborne Acoustics II
Jennifer Darrouzet	Materials Study of Plasma Sound Source Electrodes
Norma Fu	Elevating Signal Frequencies
Brian Fojtaset	Interfacing a Macintosh Personal Computer and Alliant Mainframe for Sound Speed Data Retrieval
Sirianosac Thepsoumane	Physics of Plasma Sound Source
Byron Palla	Transducer Elements as a Function of Temperature
<u>1991 Participants</u>	
Sidney P. Barnes	Optical Seawater Scattering Measurements for Use in LDV System Design

Jason Fox Manning	Analysis of a Seismo-Acoustic Experiment on the Norwegian Sea Floor
Stacy Mehevec	Biologics in the Bering Strait
Scott Beeler	Remote Data Acquisition Sub-System Clock Board
Susan Hyde	Creating a Database for Multiple Users
Tu T. Dinh	OpsStat2: An Experiment System Source Analysis Tool
Chris Rider	Development of PC Software To Display Measurements from Transit Satellite Receivers
Nathan Lusk	A Closed Cycle Repetitive Combustion Process Acoustic Sound Pulse
Linda Martinez	Development of a Computer Display for a GPS Real-Time Differential Navigation System
Christopher Holtkamp	Loss Characteristics of Corprene as a Mechanical Isolator for Ceramic Transducer Elements
Deborah Melendez	Biological Fish and Lung Experiments

Abstracts of Apprenticeship Reports

1. Denise Castillo. "Simulation by Domestic Pigs of Acoustic Properties of Human Drowning Victims, Part II," August 1990.

Recovering a human body that has drowned has proven to be very costly to society. The current method of rescue has proven to be time consuming and expensive. The divers often run into difficulties that make rescue almost impossible, e.g., low visibility. Many alternative procedures have been studied for recovering the bodies instead of the traditional use of rescue divers. This report is to verify previous results made on the "distinct phenomenon" hypothesized to be the lung as a target strength when using parametric arrays.

2. Chris Matzner. "Enhanced Nonlinear Scattering by Bubbles in Water and a Mechanism of Bubble Cloud Nonlinearity," August 1990.

It has been theoretically calculated and experimentally documented for some time that the presence of small gas bubbles in liquid enhances the effect of nonlinear sound interaction. The nonlinearity of the restoring force of a single bubble when insonified gives rise to such effects as second harmonic, sum, and

difference frequency generation as well as higher-order interaction products. The present research has followed both the theoretical and experimental aspects of nonlinear bubble acoustics.

3. A. J. Schwab. "Production of a Sonar System," August 1990.

The following report details my work as an apprentice here at the Applied Research Laboratories, in which I participated in many of the steps involved in the production of a complete sonar system. Overall, my work can be divided into three categories - production, quality control, and computer activity. All three types of work proved to be learning experiences by offering many "hands-on" opportunities that I had never had. My work was interesting and also introduced me to the wide variety of processes that take place in a research lab such as ARL.

4. Stephen Fisher. "Airborne Acoustics II," August 1990.

The following report is a summary and discussion of the high school intern project entitled Airborne Acoustics II. It deals with the feasibility of finding the acoustic signatures of different types of aircraft. The project was completed during the summer of 1990 at Applied Research Laboratories (ARL) and the report was finished on August 16, 1990.

5. Jennifer Darrouzet. "Materials Study of Plasma Sound Source Electrodes," August 1990.

The purpose of this project was to investigate why and how the material properties of the electrodes in a plasma sound source system affect their lifespans. Several materials were researched for comparisons of properties, with the one material that seemed most successful in actual tests receiving most of the focus. Through further examination of the primary material using a scanning electron microscope, several discoveries and suggestions for further study were made.

6. Norma Fu. "Elevating Signal Frequencies," August 1990.

This project examines the effects of shifting and expanding low frequency signals to evaluate them into the audible range. Four different types of waves, and variations of those waves, provide the analyzed data. The advantages, disadvantages, and possible applications of each method are presented. Appendices offer the programs used, as well as graphical evidence of the tested waves.

7. Brian Fojtaset. "Interfacing a Macintosh Personal Computer and Alliant Mainframe for Sound Speed Data Retrieval," August 1990.

This report provides an account of the steps and procedures taken to complete an Apple Macintosh-Alliant Mainframe interface and retrieval of sound speed profiles. Also a tracing of the programs, including those written in C and Hypercard Script, designed to access the Alliant's GDEM (**G**eneralized **D**igital **E**nvironmental **M**odel) data are supplied.

8. Sirianosac Thepsoumane. "Physics of Plasma Sound Source," August 1990.

This summer research project is composed of: comprehending high power, low frequency electrode projectors, manufacturing the electrodes, collecting and processing voltage, current, and hydrophone data, and analyzing any correlating data, and finally contemplating sparking characteristics.

9. Byron Palla. "Transducer Elements as a Function of Temperature," August 1990.

The purpose of this project was to determine the relationships between physical qualities shown in transducers and the temperature of the environment, and to compare the relationships shown by elements made at ARL:UT to those shown by elements made by a commercial company, where temperature stabilization procedures are carried out.

10. Sidney P. Barnes. "Optical Seawater Scattering Measurements for Use in LDV System Design," August 1991.

My task was made up of three objectives. First, I would have to redesign the analysis software for the system so that it would function more efficiently, and so that it would provide more information from the data. My second task was to help find a fault in the experimental setup which was causing reproducibility problems, and finally, I was supposed to make as many measurements as possible in the time I had left.

11. Jason Fox Manning. "Analysis of a Seismo-Acoustic Experiment on the Norwegian Sea Floor," August 1991.

My project was to move data collected during 1990 in the Vestfiord in the Norwegian Sea during sea trials conducted by SACLANTCEN to a Macintosh IIsi, and then to analyze the data, in particular to study the *similarity* (or dissimilarity) of signals that arrive over different paths to the receiver elements.

12. Stacy Mehevec. "Biologics in the Bering Strait," August 1991.

Much research and many articles have been published on identifying certain mammals living in the ocean by their repetitive calls they maintain year after year. The following research has tried to identify biologics in the Bering Strait following this guideline.

13. Scott Beeler. "Remote Data Acquisition Sub-System Clock Board," August 1991.

The purpose of this technical paper is to document the design, assembly, programming, and test procedures used during the fabrication and evaluation of the RDAS clock board.

14. Susan Hyde. "Creating a Database for Multiple Users," August 1991.

This report provides an account of the steps and procedures taken to complete a multi-user database/program for administrative purposes in the Tactical Systems Division (TSD) section.

15. Tu T. Dinh. "OpsStat2: An Experiment System Source Analysis Tool," August 1991.

Currently, OPS5 programs are run using OPS5c system. OPS5c translates OPS5 source code to C source code which can then be compiled into an executable. There is a need of support tools for an ongoing expert system project using the OPS5 expert system language. Therefore, the purpose of this project was to write an OPS5 program which analyzes the source code of other OPS5 programs and produces statistics relevant to the performance of the compiler. These statistics may aid in the improvement of the compiler output code and, therefore, lead to the improvement of the run-time performance of the OPS5c system.

16. Chris Rider. "Development of PC Software To Display Measurements from Transit Satellite Receivers," August 1991.

The following report details my role as an Apprentice at Applied Research Laboratories, The University of Texas at Austin (ARL:UT). A PC based graphics software package, called Quinn-Curtis, was the primary focus of my work. Enhancing its implementation through the use of shells is described. Implementation of the software into a newly created satellite visibility program is also discussed along with an evaluation of Quinn-Curtis' useability.

17. Nathan Lusk. "A Closed Cycle Repetitive Combustion Process Acoustic Sound Pulse," August 1991.

Several patents were uncovered regarding repeatable combustion acoustic sources which were the basis of this research. Low frequency sound generation has always been of much interest to sonar research scientists and this method has the potential to become a reliable, repeatable, inexpensive method.

This research project is to be the first in a series of steps to design and test a possible new technique for improved underwater sound sources used in active long-range sonar systems. This first step was to design, test, and collect data from a simple prototype.

18. Linda Martinez. "Development of a Computer Display for a GPS Real-Time Differential Navigation System," August 1991.

My project was to develop a computer display for a GPS Real-time Differential Navigation System. It consisted of learning FORTRAN as well as GPS, experiencing the frustrations of debugging my work, and relief when the problems were finally solved. In order to fully understand the purpose behind designing this display you should have some knowledge of a GPS Real-time Differential Navigation System.

19. Christopher Holtkamp. "Loss Characteristics of Corprene as a Mechanical Isolator for Ceramic Transducer Elements," August 1991.

The purpose of this project was to examine the loss characteristics of corprene as a mechanical isolator for ceramic transducer elements.

20. Deborah Melendez. "Biological Fish and Lung Experiments," August 1991.

In a meeting with representatives of the Texas Parks and Wildlife (TPW) Law Enforcement Division, staff members of the Applied Research Laboratories of The University of Texas (ARL) proposed the use of sonar technology to solve two problems for the TPW, locating illegal fish traps and finding human drowning victims. ARL's objective is to obtain a sonar system capable of both detecting traps and gill nets, and distinguishing them from logs, debris, and free schools of fish. To accomplish this, various sonar systems have been examined to assess their feasibility for the job. Additionally, the acoustical properties of illegal fish traps and nets have been measured, in an attempt to determine the parameters necessary for the desired system. The final section of this report covers target strength measurements made on lung tissue and image recordings of lungs by various sonar systems.

2.8 ONR SITE VISIT

On 4-5 September 1991, an ONR-appointed review committee visited ARL:UT and heard presentations on projects funded by the subject contract. These presentations were assembled in hard copy and distributed to the participants. The review committee consisted of

Phillip B. Abraham	NRL/ONR
LCDR Gary Callie	OP21, CNO
Joe Blue	NRL/ONR
Richard Stern	APL/PSU
Dan Ramsdale	NOARL
Ralph Baer	ONR
Phil Spector	OP21, CNO
Laura Davis	NRL
David Bradley	NRL
John Harlett	APL:UW

The committee provided ARL:UT with an annotated list of constructive criticisms on the research program.

3. SUMMARY AND CONCLUSION

A large inventory of research projects has been surveyed with a view toward identifying and summarizing the work done. Bibliographical data were provided so that the documented results on all of these projects can be accessed, and quality assessments can be made.

Most of the research efforts were small but unique projects involving individual efforts. These range from summer research tasks done by high school graduates to Ph.D. dissertations. A larger, focused research task on structural acoustics was initiated in FY90 and continued in FY91.

In general, the results, which are well documented in the archival literature and in other literature, are considered to be an excellent and worthy justification for the expenditure of funds under this program.

REFERENCES

1. ARL:UT Proposal Ser P-1502, dated 17 August 1989, from Michael Pestorius, ARL:UT Director, to Dr. Marshall Orr, ONR Code 1125OA, for $279,300 for the performance period 1 October 1989 - 20 September 1990.

2. ARL:UT Proposal Ser P-1512, dated 20 March 1990, from Michael Pestorius, ARL:UT Director, to Dr. Marshall Orr, ONR Code 1125OA, a modification adding an additional project, for $20,000, for the performance period 1 October 1989 - 30 November 1990.

3. ARL:UT Proposal Ser P-1522, dated 26 September 1990, from Michael Pestorius, ARL:UT Director, to Dr. Marshall Orr, ONR Code 1125OA, for $291,050, for the performance period 1 December 1990 - 30 November 1991.

4. ARL:UT Proposal Ser P-1550, dated 3 September 1991, from Michael Pestorius, ARL:UT Director, to Dr. Marshall Orr, ONR Code 1125OA, a modification adding an additional project, for $8,000, for the performance period 1 October 1989 - 31 August 1992.

19 May 1992

DISTRIBUTION LIST FOR
ARL-TR-92-9
ANNUAL REPORTS UNDER GRANT N00014-90-J-1366,
FY90 AND FY91

Copy No.

Office of the Chief of Naval Research
Department of the Navy
Arlington, VA 22217-5000
1 Attn: F. E. Saafeld (Code 10)

Director, Research Program Department
Office of the Chief of Naval Research
Arlington, VA 22217-5000
2 Attn: B. B. Robinson (Code 11)
3 L. Johnson (Code 1125)
4 R. Baer (Code 1125OA)
5 M. Orr (Code 1125OA)
6 M. Blizzard (Code 1125OA)
7 P. B. Abraham (Code 1132)
8 L. E. Hargrove (Code 1112)

Director, Special Programs Office
Office of the Chief of Naval Research
Department of the Navy
Arlington, VA 22217-5000
9 Attn: D. E. Polk (Code 11SP)

Director, Mathematical & Physical Sciences Directorate
Office of the Chief of Naval Research
Department of the Navy
Arlington, VA 22217-5000
10 Attn: B. R. Junker (Code 111)

Director, Environmental Sciences Directorate
Office of the Chief of Naval Research
Department of the Navy
Arlington, VA 22217-5000
11 Attn: E. O. Hartwig (Code 112)

Director, Engineering Sciences Directorate
Office of the Chief of Naval Research
Department of the Navy
Arlington, VA 22217-5000
12 Attn: A. M. Diness (Code 113)

Distribution list for ARL-TR-92-9 under Grant N00014-90-J-1366 (cont'd)

Copy No.

Director, Life Sciences Directorate
Office of the Chief of Naval Research
Department of the Navy
Arlington, VA 22217-5000
13 Attn: S. F. Zornetzer (Code 114)

14 - 25 Commanding Officer and Director
Defense Technical Information Center
Bldg. 5, Cameron Station
5010 Duke St.
Alexandria, VA 22314

Director
Naval Research Laboratory
Department of the Navy
Washington, D. C. 20375
26 - 27 Attn: Code 2627

Director
Applied Physics Laboratory
The Pennsylvania State University
P.O. Box 30
State College, PA 16804
28 Attn: L. R. Hettche
29 R. Stern

Director
Applied Physics Laboratory
The University of Washington
1013 N.E. 40th Street
Seattle, WA 98105
30 Attn: R. C. Spindel
31 J. Harlett

Director
Marine Physical Laboratory
The University of California, San Diego
San Diego, CA 92152
32 Attn: K. M. Watson

The University of Texas at Austin
Department of Physics
Austin, TX 78712
33 Attn: Austin M. Gleeson

Distribution list for ARL-TR-92-9 under Grant N00014-90-J-1366 (cont'd)

Copy No.

	The University of Texas at Austin Department of Physics Austin, TX 78712
34	Attn: Thomas A. Griffy
	The University of Texas at Austin Department of Mechanical Engineering Austin, TX 78712
35	Attn: Mark Hamilton
	The University of Texas at Austin Department of Computer Science Austin, TX 78712
36	Attn: Daniel P. Miranker
	The University of Texas at Austin Department of Aerospace Engineering Austin, TX 78712
37	Attn: Ronald Stearman
	The University of Texas at Austin Department of Astronomy Austin, TX 78712
38	Attn: Ethan T. Vishniac
39	Garland R. Barnard, ARL:UT
40	David Brant, ARL:UT
41	Nicholas P. Chotiros, ARL:UT
42	Glen E. Ellis, ARL:UT
43	Douglas J. Fox, ARL:UT
44	Thomas G. Muir, ARL:UT
45	F. Michael Pestorius, ARL:UT
46	Robert L. Rogers, ARL:UT
47	Gary R. Wilson, ARL:UT

Distribution list for ARL-TR-92-9 under Grant N00014-90-J-1366
(cont'd)

Copy No.

48	Library, ARL:UT
49 - 56	Reserve, ARL:UT